CEMP-ET

DEPARTMENT OF THE ARMY
U.S. ARMY CORPS OF ENGINEERS
Washington, DC 20314-1000

ETL 1110-3-490

Technical Letter
No. 1110-3-490

13 May 1998

Engineering and Design
DESIGN OF CHEMICAL AGENT COLLECTIVE PROTECTION SHELTERS
FOR NEW AND EXISTING FACILITIES

Distribution Restriction Statement

Approved for public release; distribution is unlimited.

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1. Purpose. This Engineer Technical Letter (ETL) provides information and guidance for the design of collective protection (CP) systems for new and existing facilities. Collective protection provides a toxic-free area (TFA) where personnel can function without individual protective equipment such as a mask and protective garments.

2. Applicability. This ETL applies to all HQUSACE elements and USACE commands having military construction responsibility.

3. References Appendix A contains a list of referenced and related publications

4. Distribution. Approved for public release; distribution is unlimited.

5. Background. A chemical threat to personnel can come from terrorist or wartime attacks Protection of personnel during these events can be achieved by evacuation from the affected area or by the use of shelters. When evacuation is logistically impossible, passive shelters that use only sealing measures will provide protection for a short period. For long durations, a preplaced collective protection overpressure system is required.

6. Action. Pending publication of permanent guidance, the enclosed information will be used to assist HQUSACE, major subordinate commands, district offices, and FOA in the management and design of collective protection systems.

7. Implementation. This letter will have routine application for all future military projects as defined in paragraph 8c, ER 1110-345- 100.

FOR THE COMMANDER:

KISUK CHEUNG, P.E.
Chief, Engineering and Construction Division
Directorate of Military Programs

3 Appendices
App A - References
App B - Collective Protection Requirements for Existing and New Facilities
App C - Two-Stage Airlock Design and Processing Procedures

APPENDIX A
REFERENCES

1. TM 5-810-1, "Mechanical Design Heating, Ventilating, and Air Conditioning,"15 June 1991.

2. TM 5-855-1, "Design and Analysis of Hardened Structures to Conventional Weapons Effects."

3. ER 1110-345-100, "Design Policy for Military Construction"

4. MS MIL-F-51079D, "Filter Medium, Fire-Resistant, High-Efficiency," 17 February 1988.

5. MIL-PRF-32016(EA), "Performance Specification Cell, Gas Phase, Adsorber," 26 November 1997.

6. MIL-STD-282, "Filter Units, Protective Clothing, Gas-Mask Components and Related Products: Performance-Test Method."

7. FM 3-4, "NBC Protection," 29 May 1992.

8. EA-C-1704, "Carbon-Activated, Impregnated, Copper-Silver-Zinc-Molybdenum-Triethylene diamine (ASZM-TEDA)," U.S. Army Edgewood Research, Development and Engineering Center (ERDEC), Aberdeen Proving Grounds, Maryland, 1992.

9. ERDEC-TR-336, "Expedient Sheltering in Place: An Evaluation for the Chemical Stockpile Emergency Preparedness Program," U.S. Army Edgewood Research, Development and Engineering Center (ERDEC), Aberdeen Proving Grounds, Maryland, June 1996.

10. ASHRAE "Handbook of Fundamentals," 1997.

11. ASHRAE 52.1, "Gravimetric and Dust-Spot Procedures for Testing Air-Cleaning Devices Used in General Ventilation for Removing Particulate Matter," 1992.

13. ASME AG-1a, Section FC, "Code on Nuclear Air and Gas Treatment," 1996.

13. ASME N509, "Nuclear Power Plant Air-Cleaning Units and Components," 1989.

14. ASME N510, "Testing of Nuclear Air Treatment Systems," 1989.

15. UL 586, "High-Efficiency, Particulate, Air Filter Units," 1996.

16. ASTM E779, "Standard Test Method for Determining Air Leakage Rate by Fan Pressurization," 1987.

APPENDIX B

COLLECTIVE PROTECTION REQUIREMENTS FOR EXISTING AND NEW FACILITIES

B-1. Facility Classification for Collective Protection Design.

New collective protection facilities with an integral contamination control area (CCA) will be designed in accordance with TM 5-855-1 and other criteria as designated by the using command or authority having jurisdiction. Existing and new facilities can be separated into four classes that reflect their potential to support the integration of a collective protection (CP) system.

a. *Class I.* A Class I facility is capable of fully integrating the CP overpressure system with the facility heating, ventilating, and air-conditioning (HVAC) system. The HVAC system may not be specifically designed for a CP overpressure system, but it is capable of fully maintaining the facility temperature during CP system operation. The CCA can be permanent construction inside the facility or under an open-air overhang, roofed shelter, or tent.

b. *Class II.* A Class II facility HVAC system is capable of partial integration of the CP overpressure system. The HVAC system may require upgrades to existing ductwork and isolation of the ductwork used for normal HVAC facility operations. The HVAC system may not be capable of maintaining original design conditions without modification and may require supplemental heating and cooling to be provided with the CP system. The CCA can be permanent construction inside the facility or under an open-air overhang, roofed shelter, or tent.

c. *Class III.* A Class III facility HVAC system is not capable of integrating the CP overpressure system. The facility design temperatures cannot be maintained without supplemental heating and cooling from the CP overpressure system. The CCA is under an open-air overhang, roofed shelter, or tent.

d. *Class IV.* A Class IV facility is not capable of maintaining overpressure without extensive sealing. Therefore, it is only suitable for use with the addition of an inflatable CP shelter. This type of arrangement allows the existing HVAC system to partially or fully maintain the facility design temperature outside the inflatable shelter.

B-2. Guidance.

a. *Designation for Collective Protection.* The commander or authority having jurisdiction determines if facilities are susceptible to a chemical threat and which facilities require collective protection.

b. *Existing Facilities.* Existing facilities designated to have a CP overpressure system will be modified in accordance with this appendix. Expedient collective protection sealing measures for existing facilities without a CP overpressure system will be based on the recommendations in ERDEC-TR-336.

c. *New Facilities.* New facilities designated to have a CP overpressure system, or to incorporate design features that ease future installation of a CP system, will incorporate the requirements discussed in this appendix.

B-3. Design Requirements. Major considerations for the design of CP systems for both existing and new facilities are listed below. Requirements for each item are discussed in subsequent paragraphs.

a. *Button-Up Period and TFA Floor Area Requirements.*

b. *TFA Envelope.*

c. *Airlock Requirements.*

d. *TFA Overpressure.*

e. *TFA Envelope Air Leakage Rate and Sealing Measures.*

f. *CP Overpressure System Design.*

g. *CP Control System and Operational Requirements.*

h. *Operation and Maintenance.*

B-4. Button-Up Period and TFA Floor Area Requirements.

The CP button-up period is determined by the command or authority having jurisdiction and can range from a few hours to several days. For terrorist attacks, the button-up period is usually less than 24 hours. Button-up periods longer than 24 hours are generally restricted to wartime. The button-up period influences the floor area requirements and the amount of consumable and waste storage. Generally, the button-up period will not significantly affect the performance of the CP system.

a. *Less Than 24 Hours.* A button-up period less than 24 hours does not require rest and relief areas. The minimum floor area is approximately 20 ft^2/person.

b. *More Than 24 Hours.* A button-up period greater than 24 hours requires rest and relief areas. The minimum floor area, with the use of single size beds, is approximately 60 ft^2/person. With the use of bunked beds, the minimum floor area is approximately 30 ft^2/person.

B-5. TFA Envelope.

The total required TFA floor area is determined from the button-up period, the number of people sheltered, and the required floor area per person. Generally, large open areas; e.g., common areas, multipurpose areas, gymnasiums, etc., provide the most efficient floor area for protecting a large number of personnel. The TFA envelope should include bathroom facilities and, if possible, kitchen facilities.

B-6. Airlock Requirements.

Personnel that ingress and egress the TFA during CP operations must process through an airlock. The airlock maintains TFA overpressure, prevents the migration of airborne contaminants into the TFA, and purges personnel entering the TFA. The number of airlocks required depends on the number of personnel that ingress and egress during a given time period.

a. *Stand-Alone Airlock.* For existing facilities, the stand-alone two-stage airlock discussed in Appendix C will be used. This airlock is designed to process two people into the facility within 8 minutes with 4 minutes in the first stage and an additional 4 minutes in the second stage. An integral 340 m^3/hr (200 cfm) air filtration unit is used to provide the necessary air purge rate upon which the dwell time is based.

b. *Integral Airlock.* For new facilities, an integral single-stage airlock will be incorporated into a vestibule area. The airflow purge rate through the single-stage airlock will be based on equation B-1.

$$Q = \frac{6.9V}{T} \qquad (eq.\ B\text{-}1)$$

where:
Q = airflow, cubic meters per minute
V = airlock volume, cubic meters
T = purge time, minutes

Airlock airflow is driven by internal overpressure from the TFA. Uncontaminated air from the TFA will enter the airlock near the ceiling and exhaust near the floor. The airflow rate through the TFA will be monitored by an airflow measuring station or measuring device that can be field calibrated, and the airflow rate will be displayed at a CP control panel. The airflow rate through the airlock will be controlled by a one-way flow control gravity damper. A warning light will

illuminate when the airflow rate drops below design values. The static air pressure drop from the TFA to the airlock and from the airlock to the exterior will not be more than 25 pascals (0.1 inch wg) at each location, giving a total airlock static pressure drop of 50 pascals (0.2 inch wg).

B-7. TFA Overpressure.

The minimum TFA overpressure will be 75 pascals (0.3 inch wg). This corresponds to a wind speed impact pressure normal to a wall of 40 km/hr (25 mph). At wind speeds of 24.1 km/hr (15 mph) and higher, airborne contaminants are diluted to a level of greatly reduced hazard. After installation of the overpressure system, it is possible that a TFA pressure higher than the 75 pascals (0.3 inch wg) will result. The resulting higher pressure will provide a higher factor of safety for the CP system and should not be intentionally lowered to maintain the 75 pascals (0.3 inch wg) overpressure.

B-8. TFA Envelope Air Leakage Rate and Sealing Measures.

a. *Existing Facilities.* For existing facilities, a pressurization test using a blower door assembly will be performed in accordance with ASTM E779. Test data will be plotted on a log-log graph for ease of data extrapolation and review. Air leakage locations can be identified during pressurization testing when the blower door assembly is operated in the negative pressure mode and draws outside air into the proposed TFA. These leakage locations can be identified by physical inspection or with smoke testing. Leakage areas will be sealed with a good quality sealant or, if necessary, reconstructed. Weatherization-type sealing measures can be expected to achieve leakage reductions in the range from 5 to 50 percent depending on the type and quality of facility construction. Sealing of the TFA envelope will reduce the air leakage rate and thus reduce the required amount of filtered air. Sealing measures must be economical when compared to the cost of the filtration and HVAC equipment and, for continuously operated CP facilities, energy usage needs must also be considered. After sealing, a second blower test will be conducted to determine the final TFA envelope air leakage rate.

b. *New Facilities.* For new facilities, the TFA envelope leakage rate will be calculated using the effective leakage area procedures in the ASHRAE Handbook of Fundamentals. Leakage calculations will be performed for the TFA envelope including the walls, roofs, floors, doors, windows, sole plates, mechanical and electrical penetrations, ceiling-wall joints, isolation dampers, etc. The overpressure of the TFA will be used as the differential pressure in determining the TFA envelope leakage rate. Care should be taken during design and construction to ensure that proper sealing of penetrations is performed and that continuous air leakage control barriers are used in the TFA envelope. A blower door test of the TFA envelope should be performed to verify the leakage rate and ensure that the CP overpressure filtration system has sufficient capacity.

B-9. CP Overpressure System Design.

The airflow capacity of the CP overpressure filtration system is the sum of the TFA envelope air leakage rate at the design pressure differential and the airlock airflow necessary to achieve the required purge rate. If the CP filtration system is located in a contaminated environment; i.e., outside the TFA envelope, the CP filtration system will be designed as a blow-through system with the blower located before the CP filtration system. If the CP filtration system is located in a clean environment; i.e., inside the TFA envelope, and draws in the contaminated air through a ductwork system, it will be designed as a draw-through system with the blower located after the CP filtration system. The CP filtration system blower total static pressure will be designed to include the filtration system with dirty filters, ductwork system pressure losses, and the overpressure requirement of the TFA.

a. *Filtration Systems*. The filtration system is the most critical part of the CP overpressure system. A number of filtration systems are available from both the military and commercial suppliers. If commercial filter systems are used, the mechanical system designer should have the technical expertise to prepare specifications that meet military filter system requirements. For continuously operated filter systems, accessory equipment such as moisture eliminators and sand filters will be considered for protection of the filter system as required by site conditions and design requirements.

(1) Military Filtration Systems. Military filtration units are typically provided as Government furnished equipment (GFE). Military equipment provided as GFE has the advantage of being pre-approved for use on Government installations while commercially available equipment requires additional Government quality testing.

(a) Fan Filter Assembly (FFA)-580. The FFA-580 filtration unit provides chemical filtration with a designed capacity of 1,020 m^3/hr (600 cfm) at 3,750 pascals (15.0 inches wg) using a 2.24 kW (3 HP) motor. The FFA-580 contains a high-efficiency particulate air (HEPA) filter and a chemical filter designed for an adsorption residence time of 0.25 seconds. The FFA-580 is designed for standby operation and is not intended for continuous duty.

1. Air Tempering. The FFA-580 unit does not provide air tempering of the filtered air. For Class I and II facilities, the filtered air can be either ducted directly into the facility air handling unit (AHU) return ductwork or discharged directly into the TFA. The existing mechanical system provides tempering of the air and must be located within the TFA envelope. If the FFA-580 unit is used to pressurize Class III facilities, the filtered outside air will be discharged directly into the TFA and the TFA temperature will approach outside ambient conditions.

2. Filtered Airflow Rate. The FFA-580 is provided with an adjustable iris valve (variable diameter orifice) at the blower inlet. This iris valve is used to maintain the airflow rate for differing

field conditions and will be field adjusted to maintain a maximum airflow rate of 1,120 m^3/hr (660 cfm). Adjusting the FFA-580 unit for this airflow rate allows the unit to maintain the minimum 1,020 m^3/hr (600 cfm) airflow rate when the HEPA filter becomes slightly loaded with dirt and atmospheric dust. Airflow rates above 1,120 m^3/hr (660 cfm) should be avoided because higher airflow rates reduce filter adsorption capacity and residence time. The FFA-580 unit does not have a prefilter, and therefore the HEPA filter will load more quickly than a filtration system with a prefilter. The FFA-580 unit requires periodic airflow testing to ensure it is maintaining an airflow rate in the range of 1,020 m^3/hr (600 cfm) to 1,120 m^3/hr (660 cfm). An airflow rate of 1,020 m^3/hr (600 cfm) will be used for design of the overpressure filtered air system and an airflow rate of 1,120 m^3/hr (660 cfm) will be used to design the HVAC system heating and cooling loads.

(b) The M49 Adsorption Filter. The M49 adsorber is a military developed and produced gas adsorber. Quality control and testing is also provided and managed by the military. The M49 filter comes in two sizes: 1,120 m^3/hr (600 cfm) and 2,040 m^3/hr (1,200 cfm). The M49 adsorber is of modular design and can be stacked in multiples to achieve a higher airflow rate. When compared to commercially available adsorber filters, the M49 requires only one stage of filtration for an airflow rate of 2,040 m^3/hr (1,200 cfm). Therefore, using the M49 will require somewhat less floor space than a commercial filter system. The M49 pressure drop is approximately 1,750 pascals (7 inches wg) lower than a comparable commercially available filter. The lower static pressure drop results in less initial blower cost due to the lower static head requirement. For CP filtration systems that operate continuously, the lower static pressure drop of the M49 results in lower operating costs. However, for CP systems that operate only when needed, the energy cost savings will be minor. The M49 carbon trays are refillable by the Government. The disadvantage of the M49 filter is its relatively high initial cost compared to commercially available filters. The M49 adsorption filter requires prefilters, HEPA filters, and test sections or test points similar to commercial filter systems. To procure the M49 filter, contact the Technical Director, U.S. Army Edgewood Research, Development and Engineering Center, ATTN: SCBRD-ENP-A/ Fixed Installation Engineer, 5183 Blackhawk Road, Aberdeen Proving Ground, MD 21010-5423.

(2) Commercial Filtration Systems. Commercial filtration systems are of modular sectional design and each section can filter 850 m^3/hr (500 cfm) to 2,125 m^3/hr (1,250 cfm) with two stages of adsorption. The CP overpressure filter system will require, in series, the following filter sections: roughing filter, prefilter, HEPA filter, and typically two stages of adsorber. Test sections can be provided with the filtration system to ease in-place leak testing of the filtration system, isolate which filter section fails the leak test, and for future leak testing of the filter system. If test sections are not used, test ports approximately 10 duct diameters before and after the filter system must be provided. The filter system will be quality assurance tested in accordance with ASME N510 and MIL-PRF-32016(EA).

(a) Filter Housing. The filter housing will be a bag-in and bag-out design conforming to the applicable sections of ASME N509, and will be constructed of type 304 stainless steel.

(b) Roughing Filter. Continuously operated filter systems will have a roughing filter with an average efficiency of 25 to 30 percent when tested in accordance with ASHRAE 52.1. The roughing filter extends the life of the intermediate filter or prefilter and reduces its change frequency.

(c) Prefilter. The prefilter or intermediate filter will have an average efficiency of 80 to 85 percent when tested in accordance with ASHRAE 52.1. The prefilter extends the life of the HEPA filter and reduces its change frequency.

(d) HEPA Filter. The HEPA filter frame and filter media will meet the construction, material, testing, qualification, and documentation requirements of ASME N509, N510, and UL 586 and will have a filter efficiency of 99.97 percent at 0.3 μm diameter particle size when tested in accordance with the MIL-STD-282 dioctyl phthalate (DOP) test method. The filter frames will meet the requirements of ASME AG-1a, Section FC. The HEPA filter medium will meet the requirements of MS MIL-F-51079D.

(e) Adsorption Filter. The adsorber charcoal media will be designed to adsorb aerosol with a minimum residence time of 0.25 seconds and will meet the requirements of MIL-PRF-32016(EA). Typically, for commercial filters, two stages are required to achieve the 0.25 second residence time at an airflow rate of 1,700 m^3/hr (1,000 cfm) to 2,125 m^3/hr (1,250 cfm). One stage of filter adsorption can be used for airflow rates from 850 m^3/hr (500 cfm) to 1,060 m^3/hr (625 cfm). For military applications, ASZM TEDA carbon conforming to EA-C-1704 will be used. A sample of the ASZM TEDA carbon will be provided by the filter manufacturer for testing at the U.S. Army Edgewood Research, Development and Engineering Center (ERDEC) as stated in MIL-PRF-32016(EA). Funding for ERDEC testing is provided by the user. Filter trays not contaminated by chemical surety materials or by super toxic materials can be refilled by the manufacturer, but any contaminated carbon must be disposed of by the owning activity in accordance with local, state, and federal regulations. A license must be obtained from the U.S. Department of Commerce before an adsorption filter containing ASZM TEDA carbon can be shipped outside the United States.

b. *HVAC Requirements.* For both new and existing facilities, an engineering evaluation will be made to ensure that the AHU heating and cooling coils and facility piping will not freeze at low outdoor ambient conditions during CP operations. If necessary, mechanical equipment modifications will be made to existing facilities and increased equipment capacities provided for new facilities. Class II and III facilities may require that the CP system have partial or full heating or cooling capability. The HVAC system must be designed, located, operated, and maintained to provide uncontaminated air to the TFA. These requirements depend on the facility mission requirements and must be coordinated with the user.

(1) Indoor Design Temperatures. Indoor dry and wet bulb design temperatures will be determined in accordance with TM 5-810-1, associated references, and mission requirements.

(2) Outdoor Design Temperatures. The outdoor design temperature will determined in accordance with TM 5-810-1 and associated references.

(3) Outside Air Occupant Ventilation Rate. The target outside air intake rate per occupant will be 17 m^3/hr (10 ft^3/min) and, if necessary, a minimum outside intake rate of 8.5 m^3/hr (5 ft^3/min) will be allowed. Normally, the filtered outside intake rate required to pressurize the TFA will exceed the required occupant ventilation rate.

c. *TFA Envelope Isolation and Control.*

(1) Ductwork. Ductwork that serves the TFA during normal operation but is not required during CP operations will be closed off and isolated by use of low-leakage dampers at the TFA envelope. During CP operations, the TFA overpressure system will maintain pressure on the isolation dampers under all conditions and thereby eliminate entrance of contaminated air into the TFA. Isolation damper position indicators will be included to provide visual identification of the open and closed positions. Additionally, the isolation damper position will be visually annunciated at the system control panel. The leakage rating of the isolation dampers will be selected based on an economical comparison of damper leakage and additional filtration capacity.

(2) Doors. Doors at the TFA envelope will be weather sealed to reduce the air leakage rate. The door position will be monitored and visually annunciated at the system control panel.

B-10. CP Control System and Operational Requirements.

The CP control system will be located in the TFA, preferably in a utility room. The CP system will be energized by one control panel switch that de-energizes other facility systems not required during CP system operations. Examples of these systems are normal outside air fans, exhaust fans, and recirculation fans that are in the building but outside the protected envelope. The control system will monitor the position of all isolation dampers and doors by use of an annunciator light at the control panel. All device positions; i.e., either open or closed, will be annunciated at the CP control panel. A green indicator light will annunciate if the damper or door is in the correct position during CP system operation. A red indicator light will annunciate if the damper or door is not in the correct position or if a problem has occurred. The TFA overpressure, with reference to the atmosphere, will be monitored and displayed on the CP control panel. To maintain the TFA overpressure, the airlock doors must not be opened simultaneously.

B-11. Operation and Maintenance.

a. *CP System Operational Testing.* The CP system should be tested once each month to ensure that it is in good operating condition.

b. *Filter System.* In addition to the manufacturer's recommended maintenance requirements, the following filter replacement and testing requirements should be followed.

(1) HEPA Filter. The initial resistance of the HEPA filter is typically 250 pascals (1.0 inch wg). The HEPA filter should be replaced when it is loaded and the static pressure differential reaches about 750 pascals (3.0 inches wg). The HEPA filter pressure drop will be monitored at the CP system control panel with annunciation when the dirty filter pressure drop is reached.

(2) Adsorption Filter. The adsorber filter should be replaced as required in FM 3-4 and mechanical leak tested with a fluorocarbon refrigerant gas after filter replacement.

(3) Airflow Testing. The filtration system airflow rate should be periodically tested and rebalanced as necessary to maintain the design airflow rate. The filtration system should also be airflow tested after prolonged use. A HEPA filter without a prefilter could be fully loaded after 3 months of continuous use.

(4) Filtration System Testing. The filtration system will be field leak tested by an independent testing agency after installation. The system should also be leak tested every 18 months and after replacement of the HEPA filter or adsorber filter. The design must ensure that adequate filter access is provided.

c. *Signage.* Doors required to be closed during overpressure will be labeled as such on red background signage. Doors required to remain open during overpressure will be labeled as such on green background signage.

d. *Training.* Training should be conducted for all facility personnel that may be called upon to operate the CP system.

e. *Operating Instructions.* Operating instructions and system diagrams for the CP system will be displayed next to the CP system control panel at eye level. Operating instructions will describe, in short and concise language, the steps required to operate the CP system. All CP system control switches and indicators will be clearly marked and identified.

f. *Operation and Maintenance Manual.* An operation and maintenance manual will be provided and will contain system operating instructions, emergency operation instructions, preventive maintenance information, troubleshooting, corrective maintenance, critical instructions, and a spare parts list.

B-12. Additional Assistance

Additional assistance is available at the Protective Design Mandatory Center of Expertise. They can be reached at:

U.S. Army Engineer District, Omaha
ATTN: CENWO-ED-S
215 North 17th Street
Omaha, NE 68102-4978
(402) 221-4925/4918

APPENDIX C

TWO-STAGE AIRLOCK DESIGN AND PROCESSING PROCEDURES

C-1. Airlock Description.

As shown in Figure C-1, the two-stage airlock has outer first stage and inner second stage compartments. The outer compartment is used to remove protective garments while it is being continuously purged by the flow of filtered air. After protective garments are removed, personnel enter the inner compartment which is then purged of vapors during the dwell cycle. After the dwell period, personnel enter the toxic-free area (TFA). Clean airflow for these cycles is provided by a dedicated filter blower unit connected to the inner compartment at the filtered air inlet.

C-2. Airlock Features.

The following features are common to an integral or stand-alone airlock.

a. *Timers.* A mechanical bell timer to time the dwell and purge cycles is required in each compartment.

b. *Windows.* A window is required at each compartment to determine if it is occupied.

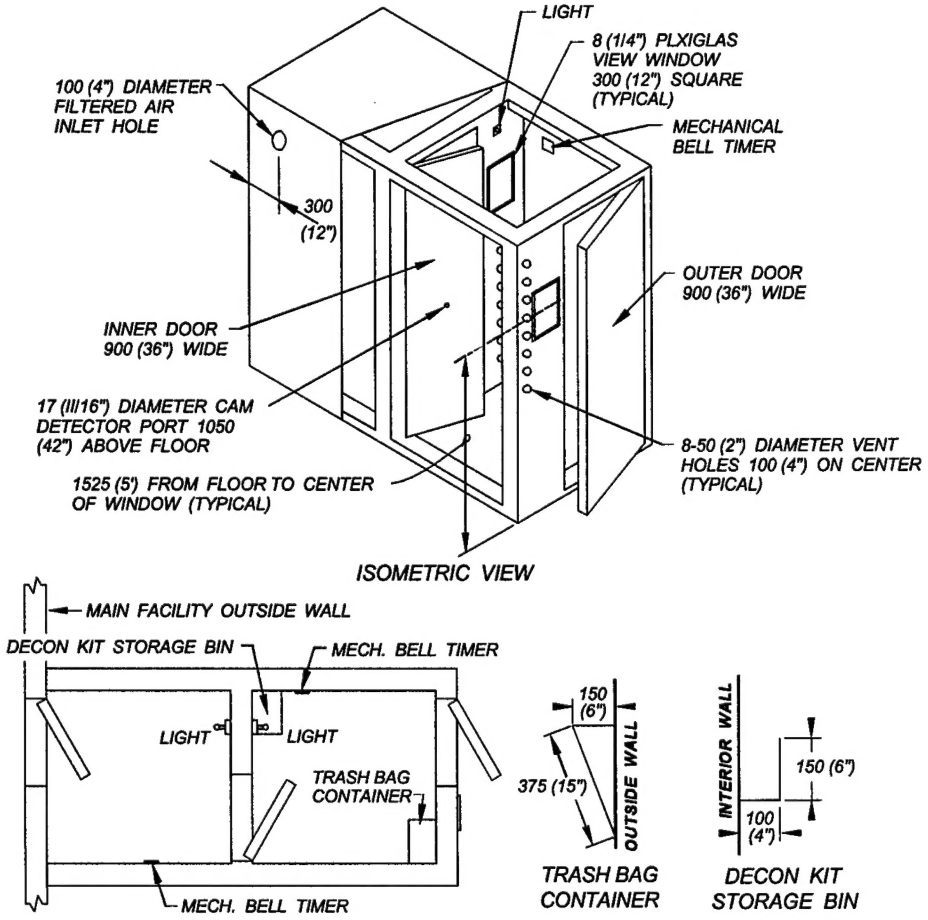
c. *Lights.* Lights are required because the interior lacks adequate natural lighting.

d. *Purge Vents.* The two-stage airlock has fixed rather than adjustable purge vents because it has a dedicated filter blower unit that makes the airflow rate easy to maintain. For an airlock without a dedicated filter blower unit, a variable area purge vent or flow control valve is required to adjust the airflow rate and maintain the required purge rate.

e. *Monitoring Port.* The monitoring port allows the chemical agent monitor (CAM) detector inlet to be inserted into the outer compartment by a CAM operator located in the inner compartment. This allows the CAM operator to determine if there is agent vapor in the outer compartment. With a negative reading in both the G and H mode (about 10 seconds each), the operator may determine that a shorter or longer dwell period is required. A second CAM check for sorbed vapor can then be performed in the inner or second stage compartment.

f. *Caulking.* Caulking should be applied to all joints to limit uncontrolled air leakage.

g. *Paint.* Painting the interior and exterior surfaces with epoxy paint is required to minimize the sorption of liquid and vapor agents.



NOTES:

1. AIRLOCK INNER AND OUTER COMPARTMENTS ARE 1520 (60") BY 990 (39") BY 2130 (7') HIGH MEASURING FORM INTERIOR SURFACES.
2. THE TRASH BAG CONTAINER AND DECON KIT STORAGE BIN ARE 375 (15") LONG.
3. VENT HOLES ON THE OUTER WALL START 125 (5") FROM THE CEILING. VENT HOLES ON THE INNER WALL START 125 (5") FROM THE FLOOR.
4. MECHANICAL BELL TIMERS ARE 1830 (6') ABOVE THE FLOOR.
5. THE FILTERED AIR INLET HOLE IS 300 (12") BELOW THE CEILING.

Figure C-1. Two-Stage Airlock Diagram.

h. *Instructional Signs.* Basic instructions must be provided on the outer and inner doors.

i. *Clothing Chute or Trash Bag Container.* A clothing chute allows contaminated clothing to be removed from the airlock and discarded outdoors without re-exposure of personnel to the contaminated atmosphere. As an alternative, plastic trash bags can be placed in the airlock so that personnel can seal clothing in the bag after removal. The bag is then removed by the next group entering the airlock. If a clothing chute is not provided, a trash bag container should be provided.

C-3. Recommended Airlock Signs.

Recommended signs to be stenciled on the airlock are shown in Table C-1.

Table C-1
Airlock Signs

Sign	Location
1. Two-Stage Airlock	1. Above the outer door.
2. Do Not Open if Airlock is Occupied.	2. On the outer door.
3. Upon Entering, Set Timer for 4 Minutes.	3. On the outer door below the other sign.
4. Remove Mask Only after 4-Minute Purge and/or CAM Check.	4. On the second door, read from outer compartment.
5. Filtered Air Input	5. Near the filtered air inlet.
6. CAM Check Port.	6. On the second door above the CAM port.
7. Remove Outer Garments Before Processing to Next Compartment if Exposed to Chemical Agent.	7. On the second door, read from outer compartment, below the other sign.
8. Set Timer for 4 Minutes.	8. On the second door, read from inner compartment.

C-4. Processing Procedure Recommendations.

Processing procedures are the responsibility of the local command authority. Basic and commonly used ingress in-processing procedures are described in Table C-2. If detector paper indicates liquid contamination on outer garments, open-air decontamination may be required before entering the airlock.

Table C-2
Processing Procedures

Item	Description
1	Before entering the airlock first stage, ensure that the airlock filter blower unit is operating and that air is being discharged from the purge vents.
2	Look through the view window to ensure that the first stage is not occupied. If unoccupied, enter the airlock first stage.
3	After entering the airlock first stage, remove any items left from the previous in-processing group. Set the timer to 4 minutes. During the 4-minute dwell time, remove outer garments and put them in the trash bag or clothing chute provided.
4	When the 4-minute dwell time is complete, personnel in the second stage of the airlock should check the first stage with a chemical agent monitor to ensure that the contaminants have been sufficiently removed. After the first stage has been checked and no contaminants have been detected, proceed to the second stage.
5	After entering the second stage, set the timer for a 4-minute purge time. After the 4 minutes have elapsed, hold your breath, remove your mask, and enter the TFA. Depending on user requirements, the mask is either placed in a mask bag, sealed, and taken into the shelter for use during an emergency or the mask is left in the airlock and removed by the next processing group.